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USAID/DCHA/OFDA FOR GMAYBERRY
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SUBJECT: Mozambique: USGS and USAID/OFDA Assessment of February 23 Earthquake

Ref: Maputo 232

Maputo 241

¶1. Summary. A magnitude (M) 7.0 earthquake that occurred in Machaze, Mozambique on February 23, 2006 raised awareness that a large earthquake could occur in the country. Detailed analysis of the seismicity in Mozambique is needed to determine if a large earthquake could occur near highly populated areas or significant infrastructure such as the Cahora Bassa dam. The first step in assessing the potential seismic risk in the country is to strengthen the national seismic network in order to pinpoint the location of small earthquakes, which reveal the location of faults that have the potential for larger earthquakes in the future. A team composed of the USAID Office of U.S. Foreign Disaster Assistance (USAID/OFDA) geoscience advisor and seismologists from the U.S. Geological Survey (USGS) visited the area of the earthquake and met with key members of the local geological community to determine what is needed to strengthen the Mozambique seismic network. They determined that the highest priority was for upgrading existing seismic stations, adding seismic monitoring equipment, and training Direccao Nacional de Geologia (DNG) staff. End summary.

Overview

¶2. A large earthquake occurred in Machaze, Mozambique on February 23 at 1219 am local time (ref A). According to the USGS National Earthquake Information Center (NEIC), the earthquake had a magnitude (M) of 7. Although this was a large-magnitude earthquake, there was little loss of life and little damage because the earthquake occurred in an area with low population density where homes are constructed of light-weight, flexible materials. If an earthquake of this size occurred in a highly populated region in Mozambique, for instance the cities of Beira or Maputo, the impact could be much greater. The seismic network in Mozambique, which is used to record and locate earthquakes, is inadequate by modern standards. It consists of only four stations, three of which are equipped with obsolete seismographs and have no telecommunications capability. Accordingly, the seismic hazard in the country is not well known because the network cannot locate small earthquakes, which are indicative of where larger ones could occur.

¶3. In response to the M 7 earthquake, seismologists from the USGS, with funding from USAID/OFDA, traveled to Mozambique to work with the DNG. They evaluated the potential for large (M greater than 6) earthquakes that could pose a threat to populated regions or to critical infrastructure including the Cahora Bassa concrete arch dam on the Zambezi

river. The seismologists found that in-kind support and funding that DNG had received from other donors met some of their needs, but there is still a need to 1) upgrade existing seismic stations, 2) add new stations for better coverage, and 3) train the staff to operate and maintain the new systems as well as to analyze complex seismic data.

¶4. In order to help DNG assess the seismic hazard in Mozambique, which will help the government and at-risk communities prepare for large earthquakes, USGS proposes to cooperate with DNG for a major upgrade of the Mozambique seismic network. This proposed project will involve establishing four new stations and upgrading three current stations so that broad-band, real time data are available. The future upgraded Mozambique seismic network would consist of several broad-band stations communicating data in real time to the DNG headquarters. USGS proposes to provide technical assistance in site selection, training, and evaluation of performance. The primary goal of this proposed effort is to assist the DNG staff in developing an independent and self-sufficient Seismic-Hazard Reduction Center in Mozambique that collects and processes regional seismic data in real time and interprets these data in ways useful to the mitigation of earthquake effects.

¶5. With funding from USAID/OFDA, during July 17 through 20 two USGS seismologists and the USAID/OFDA geoscience advisor travelled to Mozambique. Their goal was to determine what assistance DNG needs in order to improve their seismic network so they can eventually issue real time earthquake notifications and produce a detailed map of the seismic hazard in the country. The group also evaluated the potential for large (M greater than 6) earthquakes to pose a threat to highly populated areas and critical facilities. While in-country they met with staff from the U.S. embassy

in Maputo, the USAID mission, Direccao Nacional de Geologia, and the administrator of Chitobe near where the earthquake occurred. In South Africa, the team met with the Resources and Science Specialist with the U.S. Consulate in Johannesburg, the USAID/OFDA Regional Advisor for southern Africa, and representatives from the USAID office of Food For Peace, the U.S. Agency for International Development (USAID), and the UN Office for the Coordination of Humanitarian Affairs (OCHA).

¶6. The trip to Mozambique was preceeded by a visit to the Africa Array workshop in Johannesburg, South Africa, during July 20 through 21. Attending the workshop allowed the assessment group to meet with the director of DNG, current and potential donors to the Mozambique seismic network, and members of the seismological community from other African countries who would be able to share seismic data with Mozambique, futher strengthening their network.

Geologic setting

¶7. The NEIC reported that the February 23rd earthquake occurred near the southern end of the East African rift system. The East African rift system is a diffuse zone of crustal extension that passes through eastern Africa from Djibouti and Eritrea on the north to Malawi and Mozambique on the south. The East African rift results from spreading between the Africa tectonic plate on the west and the Somalia plate on the east. At the earthquake's latitude, the Africa and Somalia plates are spreading apart at a rate of several millimeters per year. The largest earthquake to have occurred in the rift system since 1900 had a magnitude of about 7.6. The western branch of this rift terminates in southern Mozambique, while the eastern branch travels through Kenya and continues into Tanzania. There is persistent seismicity within the Mozambique channel, suggesting that the eastern branch of the rift may continue

into the Indian Ocean, possibly to the southwestern Indian Ocean ridge.

Field survey

¶8. The M 7 earthquake on February 23rd occurred in Machaze, the southernmost district in the western province of Manica, about 215 km (135 miles) SW of the city of Beira, Mozambique. There were reports of 4 deaths, 36 injuries, and 1,440 people made homeless. The earthquake was felt as intensity VI (strong perceived shaking, light potential damage) in Beira, approximately 215 km (135 miles) northeast of the location of the earthquake, and intensity IV (light perceived shaking, no potential damage) in Maputo, about 500 km (310 miles) to the south. Within the epicentral area (the area near where the earthquake occurred), spectacular surface faulting was seen, with a crack actually running through a traditionally built dwelling and one splitting a tree. Extensive liquefaction was also seen, which is a process by which water-saturated sediment temporarily loses strength and acts as a fluid. The maximum surface slip of about 2 meters was consistent with the large magnitude measured for this earthquake.

¶9. The primary natural hazard affecting Mozambique is flooding, a result of low-lying topography and heavy rainfall. Earthquakes, in contrast, are thought to be a much less important source of hazard, largely because the African continent generally has quite a low level of natural seismicity. Similarly, the February 23rd Machaze earthquake, although of considerable magnitude, resulted in few casualties and severe damage to only a small number of dwellings considering the size of this earthquake for several reasons. First, the epicentral region is sparsely populated. Second, houses in the epicentral area were largely undamaged because most of these structures are made of light-weight materials as was reported by seismologists from Imperial College, England, who conducted a field survey shortly after the earthquake. In contrast, many of the structures made of unreinforced brick masonry collapsed to some extent, resulting in a few fatalities. Third, earthquakes with associated surface faulting tend to yield lower levels of damaging ground motion compared to those involving buried faults (no surface rupture). Fourth, earthquakes in extensional tectonic environments, including the East African rift belts where the Machaze earthquake occurred, show lower levels of damaging ground motion

compared to their counterparts in compressional environments (e.g. Iran).

¶10. To date, relatively little attention has been paid to the potential for seismic hazards in Mozambique, which is evidenced by the archaic and sparse seismic monitoring system currently in place in the country. However, the nature and magnitude of the February 23rd Machaze earthquake has raised serious questions regarding the hazard associated with large earthquakes that might occur in densely-populated regions in Mozambique, or near critical facilities like the Cahora Bassa concrete arch dam on the Zambezi river. The Cahora Bassa dam, the 2nd largest in Africa and the 4th largest in the world, has impounded an enormous reservoir and generates 2.1 mega-watts of electricity. In the event of a nearby strong earthquake, the integrity of the dam might be compromised, resulting perhaps in flooding and loss of electrical power delivered to Mozambique, South Africa, and other neighboring countries.

¶11. Current seismic hazard maps of Mozambique lack detail and are based largely on expected seismicity associated with the East African rift. However, it is possible that other types of faulting could be present, but are not yet identified from Mozambique's limited earthquake data base.

Such additional sources of seismicity could change the hazard map to some extent. Currently the seismic network run by DNG is too sparse to record and locate earthquakes at a sufficiently low magnitude threshold to determine the likely sources of damaging ground motion due to future earthquakes. Currently, data from three of the four existing seismic stations that DNG runs are periodically retrieved manually and sent to the Council for Geosciences in South Africa for analysis, the results of which are then sent to DNG. This process, which takes at least a month, precludes the possibility of responding to major damaging earthquakes in a timely manner, and also compromises the ability of the DNG to develop a realistic seismic hazard map based on up-to-date information.

Future plan

¶12. The French embassy in Mozambique and the Council for Geoscience in South Africa have already provided DNG with computer equipment and training, respectively. Additionally, the Intergovernmental Oceanographic Commission (IOC) intends to establish three stations along the coast of Mozambique as part of the Indian Ocean tsunami warning network. Based on the results from the assessment trip and pending funding, USGS proposes to work with DNG at their request to develop a new, vastly-upgraded Mozambique seismic network that will consist of eight stations equipped with state-of-the-art seismometers, digitizers, and telemetry via cellular technology.

¶13. There are four key roles that the USGS plans to play: (1) definition of network goals and derived products, including seismic hazard maps, (2) assistance during network construction and evaluation of performance, (3) equipment acquisition and installation, and (4) training in network operations and data processing, ensuring that local scientists and engineers become independent operators of the network. The primary end-product of this network will be the production of an improved probabilistic seismic hazard map for Mozambique. This map will delineate the zones where the likelihood of damaging ground motion is the greatest so that appropriate hazard mitigation activities can be prioritized and undertaken. Additionally, USGS will advise DNG in the development of information products to help educate the public about how to prepare for large earthquakes and tsunamis.

¶14. This report was written by members of the USGS and USAID/OFDA team that visited Mozambique in July.

Dudley